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Demographic and geographical characteristics of pediatric trauma in Scotland☆,☆☆

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Abstract

Background: Trauma systems reduce mortality and improve functional outcomes. The aim of this study was to analyse the demographic and geospatial characteristics of pediatric trauma patients in Scotland, and determine the level of destination healthcare facility which injured children are taken to, to determine the need for, and general feasibility, of developing a pediatric trauma system for Scotland.

Methods: Retrospective analysis of incidents involving children aged 1–14 attended to by the Scottish Ambulance Service between 1 November 2008 and 31 October 2010. A subgroup with physiological derangement was defined. Incident location postcode was used to determine incident location by health board region, rurality and social deprivation. Destination healthcare facility was classified into one of six categories.

Results: Of 10,759 incidents, 72.3% occurred in urban areas and 5.8% in remote areas. Incident location was associated with socioeconomic deprivation. Of the patients, 11.6% were taken to a pediatric hospital with pediatric intensive care facilities, 21.8% to a pediatric hospital without pediatric intensive care service, and 50.2% to an adult large general hospital without pediatric surgical service.

Conclusions: The majority of incidents involving children with injuries occurred in urban areas. Half were taken to a hospital without pediatric surgical service. There was no difference between children with normal and deranged physiology.

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Trauma is the leading cause of death in children [1,2], and trauma systems have been shown to decrease mortality [3–7]. Time to definitive trauma care is now recognised as a key determinant of outcome [8–12] and is facilitated by triage of casualties to appropriately resourced facilities [13]. Scotland does not have a coherent framework for adult or pediatric trauma care [14], although several authorities have called for the development of such a system [15]. Current operational policy is to take casualties to the nearest hospital with an emergency department, even if the centre selected is not resourced to deal with the patient's injuries. The lack of a trauma system in Scotland is, at least in part, owing to a perception that Scotland's geography and eccentrically distributed population precludes the establishment of such a system. Delivering specialist trauma care to a mixed urban/rural population is challenging [12,16–19], and must take the geographical distribution of the incidents – which may not mirror the population distribution – into consideration.

There are no data on the distribution of pediatric trauma incidents in Scotland. The aim of this study was to analyse the demographic and geospatial characteristics of pediatric trauma in Scotland, and to determine the level of destination healthcare facility which patients were taken to.

1. Methods

This was a retrospective analysis of prospectively collected Scottish Ambulance Service (SAS) data.

1.1. Case definition

For the purpose of this study, a child was defined as a person aged between 1 and 14 years of age. Children aged less than 1 year old were not included because age was not always recorded and because the SAS's electronic patient record system only allows age to be recorded in years (rather than months). All children involved in an incident attended to between 1 November 2008 and 31 October 2010 were included. Incidents involving traumatic injury were identified using the protocol component of the MPDS (Medical Priority Dispatch System, Priority Dispatch Corp, TM, Salt Lake City, Utah) final diagnostic code. The codes extracted included assaults, falls, penetrating injuries, traffic and transport injuries, and other traumatic injuries. Mechanism of injury was also determined by MPDS code. Incidents with missing location postcodes were excluded.

1.2. Study variables

Extracted data included patient demographics, postcode of incident location, physiological data (heart rate and respiratory rate) and destination healthcare facility. The demographic and geospatial characteristics of the incidents were analysed by health board region, rurality and deprivation index. Health board region was determined using incident location postcodes, using look-up tables. Rurality was categorised using the 8-fold Scottish Urban/Rural Classification [20], which is based on settlement size and drive time to major conurbations. Social deprivation was graded into deciles of the Scottish Index of Multiple Deprivation [21], a ranked summary measure of socioeconomic status incorporating data on employment, income, health, education, access to services, crime, and housing. The primary endpoint was the designation of the destination healthcare facility to which patients were taken, categorised as pediatric hospitals with a pediatric intensive care unit (Royal Hospital for Sick Children, Edinburgh; and Yorkhill Hospital, Glasgow), pediatric hospitals without a pediatric intensive care unit (Royal Aberdeen Children's Hospital and Ninewells Hospital, Dundee), adult university hospitals, adult large general hospitals, adult general hospitals and other facilities without a pediatric surgical service. Hospitals were classified using tables available from the Scottish Government [22].

1.3. Subgroup analysis

In order to distinguish between children with minor and major injuries, a subgroup of children with "abnormal physiology" was defined. Abnormal physiology was defined as a respiratory rate or heart rate above the 90th centile or below the 10th centile of the patient's age-specific physiological reference range [23] at any time between arrival of the ambulance at the scene, and reaching the destination healthcare facility.

1.4. Statistical analysis

Multiple pivot tables were used for postcode look-ups and descriptive measures, using Microsoft Excel (Microsoft®, Redmond, Washington, USA). The midyear population estimate for 30 June 2009 was used to calculate incidence rates [24]. Data are presented as absolute numbers, medians and interquartile ranges, or proportions. Missing values were not included in the analysis. Incidence rates were calculated per 100,000 population, per year. Relative risks (RR), with confidence intervals (CI), were used to describe the likelihood of an incident relative to the remainder of the population.

2. Results

There were 10,759 incidents matching the case definition. Of these, 125 (1.2%) could not be linked to a health board region, a multiple deprivation index datazone, or an urban/rural classification category, and were excluded.

2.1. Demographics

There was a greater proportion of incidents involving males (61.1%) than females (37.2%) (Table 1). Gender was

Table 1 Characteristics of study population, overall and by physiological status.

Characteristic	Parameter	All Incidents		Abnormal Physiology		Normal Physiology	
	n	10,759		4294		6465	
Age	Median (IQR)	9	(4–12)	8	(3–12)	9	(4–13)
Gender	Male, n (%)	6575	(61.1)	2539	(59.1)	4036	(62.4)
	Female, n (%)	3998	(37.2)	1684	(39.2)	2314	(35.8)
	Missing, n (%)	186	(1.7)	71	(1.7)	115	(1.8)
Mechanism	Blunt, n (%)	10728	(99.71)	4280	(99.67)	6448	(99.74)
	Penetrating, n (%)	31	(0.29)	14	(0.33)	17	(0.26)

not recorded in 186 children (1.7%), the median age was 9 years (interquartile range 4–12) and 99.7% of incidents involved a blunt mechanism of injury. At least one abnormal physiological parameter was recorded in 4294 children (39.9%). There were no clinically significant differences in the median age or gender composition between the two groups. The age distribution was bimodal, with peaks at age 2 and age 14. In children with abnormal physiology, a greater proportion of cases involved older children and in children with normal physiology, more cases involved younger children.

2.2. Incident location by health board region

The greatest number of incidents occurred in health boards with the largest populations. The incidence rate varied from 344 to 788 incidents per 100,000 population, per year. The Western Isles, Shetland and Orkney had the lowest incidence rates, while Lothian had the highest (Fig. 1). The incidence rate of Greater Glasgow and Clyde matched that of Scotland as a whole (Table 2). The highest relative risk of an incident occurring in any health board region, compared with the rest of Scotland, was in Lothian, while the lowest relative risks were in the Western Isles, Shetland and Orkney (Table S1).

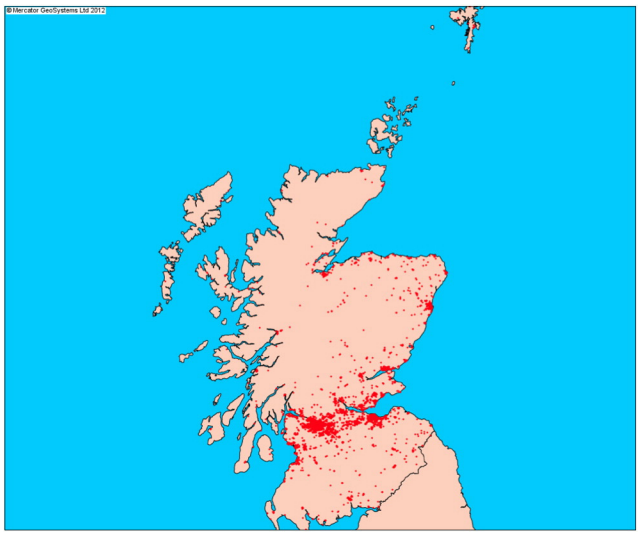

Fig. 1 Geographical distribution of incidents associated with physiological abnormality.

The number of incidents involving abnormal physiology also varied, from none in Orkney, to 1085 in Greater Glasgow and Clyde. There were 733 and 543 incidents in Lothian and Lanarkshire respectively, and an approximately equal number of incidents in Grampian, Tayside, Ayrshire and Arran, the Highlands, Forth Valley and Fife. The incidence rate was highest in Lanarkshire and Fife, but the incidence rates were broadly similar in Greater Glasgow and Clyde, Lothian, Ayrshire and Arran, the Highlands, Dumfries and Galloway and Forth Valley. Both the total number of incidents, and the incidence rates, were low in the island health boards (Table S1). The relative risks of an incident involving abnormal physiology occurring in any health board region, compared with the rest of Scotland, were highest in Greater Glasgow and Clyde, Lothian, and Lanarkshire (Table S1).

2.3. Rurality

The proportion of incidents broadly followed the population distribution, but with some exceptions. Scotland has an eccentrically distributed population, with 69.5% living in urban areas (Scottish urban/rural classification categories 1 and 2), 12.3% living in small towns (categories 3–5), 11.6% living in accessible rural areas (categories 6), and only 6.5% living in remote rural or very remote rural areas (categories 7 and 8) [27]. The proportion of incidents that occurred in urban areas was 72.3%, small towns was 10.7%, accessible rural areas was 10.2% and remote regions was 5.8% (1.2% of postcodes were unmatched). Incidence rates decreased from 704 and 711 per 100,000 population per year in large urban and other urban areas respectively, to 581 in very remote rural locations. The relative risk of an incident occurring in a large urban area or other urban area was significantly higher, while the relative risk was significantly lower in accessible small towns, accessible rural areas and very remote rural areas (Table 2). A similar decrease was seen when considering incidents involving children with abnormal physiology, from 282 in large urban areas to 182 in very remote rural areas, but was broadly similar across categories 1–7 of the classification (Table 2). The relative risk of an incident involving abnormal physiology occurring in a large urban or other urban area was significantly higher (Table 2).

Table 2 Number and incidence rates, overall and by physiology, by rural/urban classification of location.

SURC Category	Description	Population in category	All Incidents				Abnormal physiology			
			n	%	Incidence Rate	Relative Risk (95% CI)	n	%	Incidence Rate	Relative Risk (95% CI)
1	Large urban areas	307623	4332	40.3	704	1.07 (1.03–1.11)	1733	40.4	282	1.07 (1.01–1.14)
2	Other urban areas	241986	3442	32.0	711	1.08 (1.04–1.13)	1406	32.7	291	1.11 (1.04–1.18)
3	Accessible small towns	67218	760	7.1	565	0.83 (0.77–0.89)	306	7.1	228	0.83 (0.74–0.93)
4	Remote small towns	20561	266	2.5	647	0.96 (0.85–1.09)	98	2.3	238	0.88 (0.72–1.07)
5	Very remote small towns	9490	114	1.1	601	0.89 (0.74–1.07)	42	1.0	221	0.82 (0.60–1.11)
6	Accessible rural	91733	1095	10.2	597	0.88 (0.82–0.93)	429	10.0	234	0.85 (0.77–0.94)
7	Remote rural	26887	340	3.2	632	0.94 (0.84–1.05)	141	3.3	262	0.97 (0.82–1.15)
8	Very remote rural	24515	285	2.6	581	0.86 (0.77–0.97)	89	2.1	182	0.67 (0.54–0.82)
N/A	Unmatched postcodes *	-	125	1.2	-	-	50	1.2	-	-
-	Total	790804	10759	100	680	-	4294	100	271	-

* Unable to match postcode owing to changes in postcode or English postcodes.

2.4. Social deprivation

The number of incidents occurring in the most deprived areas of Scotland was almost four times that of the least deprived. The incidence rate in the most deprived areas of Scotland was 1146 per 100,000 population per year compared to 344 in the least deprived areas, a greater than 3-fold increase. The relative risk of an incident occurring in the most deprived decile was 1.84 (95% confidence interval 1.75–1.94), compared with the rest of Scotland, while the relative risk of an incident occurring in the least deprived decile was only 0.49 (95% confidence interval 0.45–0.53) (Table S2). Incidents that included children with abnormal physiology showed an even greater association with social deprivation. The incidence rate in the most deprived areas was 495 per 100,000 population per year compared to 117 in the least deprived areas – a more than 4-fold increase. The relative risk of an incident involving a child with abnormal physiology occurring in the most deprived decile was 2.01 (95% confidence interval 1.86–2.17), compared with the rest of Scotland, while the relative risk of an incident involving a child with abnormal physiology occurring in the least deprived decile was only 0.41 (95% confidence interval 0.35–0.47) (Table S2).

2.5. Destination health care facility

Overall, 11.6% of patients were taken to a children's hospital with a pediatric surgical service and a pediatric intensive care unit, and 21.8% to a children's hospital with a pediatric surgical service but without a pediatric intensive care unit. A minority were taken to an adult university hospital without pediatric surgical service (9.7%), and 50.2% were taken to an adult large general hospital without pediatric surgical service. The remainder (6.7%) were taken to a variety of smaller or specialist hospitals, again without pediatric surgical service. These proportions essentially remained unchanged when only children with physiological disturbance were considered (Table 3).

3. Discussion

Our results show that pediatric trauma in Scotland is a predominantly urban problem, strongly associated with social deprivation and that virtually all injuries are owing to blunt trauma. The geographical distribution is similar to that of adult trauma [25]. In contrast to absolute numbers, the incidence rate shows less geographical variation. In short, the chance of a child suffering trauma and being involved in an incident attended to by the SAS is similar across Scotland, but the total number of incidents – which is largely related to population size – is much greater in urban areas. This finding is key, as the design of a trauma system must be based on the number of incidents, and not the incidence rate.

Table 3 Destination healthcare facility, by physiological status.

Type of Hospital	All Incidents		Abnormal Physiology	
	n	(%)	n	(%)
Pediatric Hospital with Intensive Care Unit	1246	(11.6)	469	(10.9)
Pediatric Hospital without Intensive Care Unit	2347	(21.8)	924	(21.5)
Adult University Hospital	1042	(9.7)	407	(9.5)
Adult Large General Hospital	5400	(50.2)	2226	(51.8)
Adult General Hospital	397	(3.7)	139	(3.2)
Other (maternity, community, etc.)	327	(3.0)	129	(3.0)
Total	10759	(100.0)	4294	(100.0)

Mirroring the findings of our adult study, these findings suggest that the regionalization of pediatric trauma care in areas where the largest number of incidents occurs would provide enhanced care for the majority of children who incur injury [25]. Our results also demonstrate a mismatch between need and capability, which is explained by the current policy to take casualties – regardless of age or injury severity – to the nearest emergency department which, in most regions, is a district general hospital without pediatric surgical service. The small number of children who are injured in remote areas might therefore also be served better by a system that enables rapid transfer to definitive care.

This study has a number of limitations. The source data were derived from an electronic patient record system, rather than an audit or research database. Children aged less than one year were excluded, and data pertaining to mechanism of injury were derived from summary diagnostic codes. The inclusion criteria were broader than those used, for example, by the Trauma Audit and Research Network [26]. Reliance on pre-hospital data precludes the calculation of injury severity scores, and we therefore chose physiological criteria to define a subgroup of children with physiological derangement and – by inference – more severe injuries. This measure, although commonsensical, has not been validated and the presence of "abnormal physiology" should not be equated with "severe injury". The number of severely injured children – as defined by injury severity score – will be considerably smaller. In England, which has a population approximately ten times that of Scotland, there are estimated to be between 300–500 severely injured children per annum [26,27]. Lastly, we were unable to match a small proportion of incident location postcodes to health board regions or urban/rural classification categories. Possible reasons include inaccurately recorded postcodes, inaccuracies in the look-up tables, or changes to postcodes. The number of unmatched codes was small, and is thus unlikely to materially affect the results or conclusions.

Despite these limitations, our study adds to our understanding of pediatric trauma care in Scotland. There appears to be a need for specialist centres, and the design of such a network appears feasible. The precise configuration, which might incorporate adult, pediatric, and combined major trauma centres [27], as well as trauma units, requires further study.

Supplementary data to this article can be found online at http://dx.doi.org/10.1016/j.jpedsurg.2013.03.060.

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